PTC and Partner Products in the Creation of a Hurricane Wind Sensor

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Presentation Objectives

- Educate the user unfamiliar with the modules as to what is available/lacking
- Share with PTC employees/TC members where some changes could be made
- Look at alternative approaches made possible by new releases/modules
- Use feedback to improve my own processes/approaches

Stimulus to Solution

- Current pad wind sensors are cup-and-vane type anemometers
- Problems:
    - Moving parts
    - Slow response and recovery time
    - Relatively large profile
    - No directionality

Design Goals

- Small profile
- No moving parts
- Strain based
- Fast response and recovery
- No permanent deformation
- ~1000 μstrain under 5 lbf load at CG
  - For AL2026-T851, σ_{tar}= 10.6ksi (based on $\sigma_{tar}=E\epsilon_{tar}$)

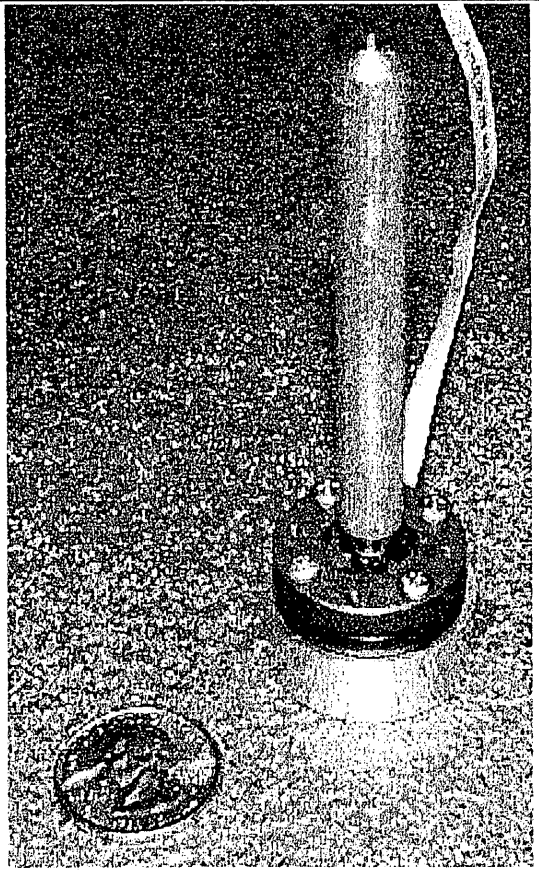
Creation of Geometry

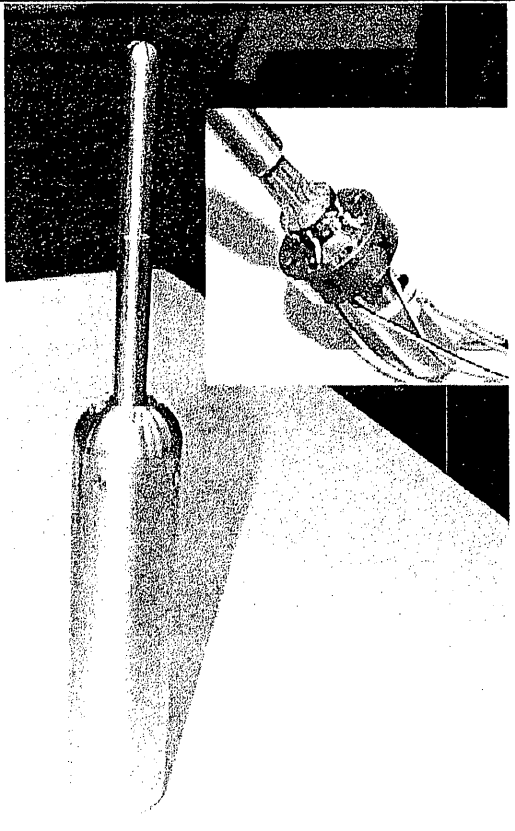
- Pro/E allowed for multiple designs to be studied
- More designs, faster, with less repeated effort
- Allowed for easy modification that carried throughout the design

Three Design Approaches

Single Leaf	Cruciform	Cantilever

Insert single-leaf picture here



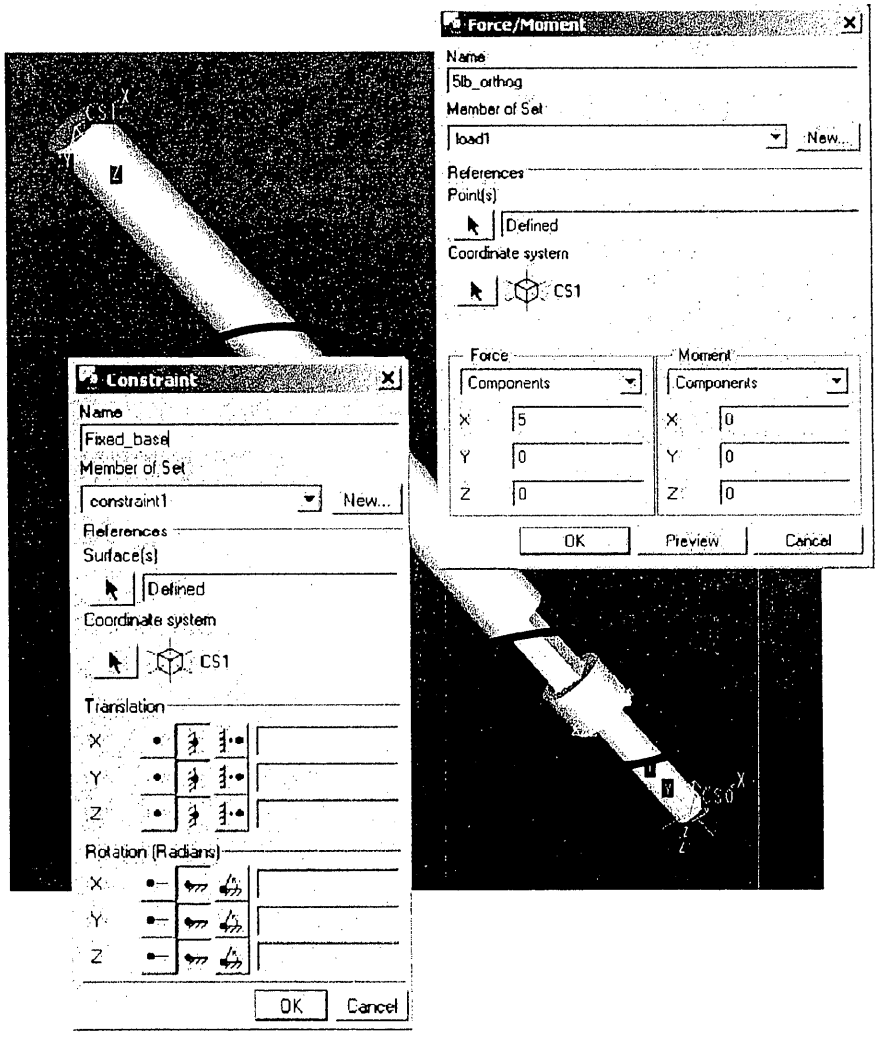


Baseline Analyses

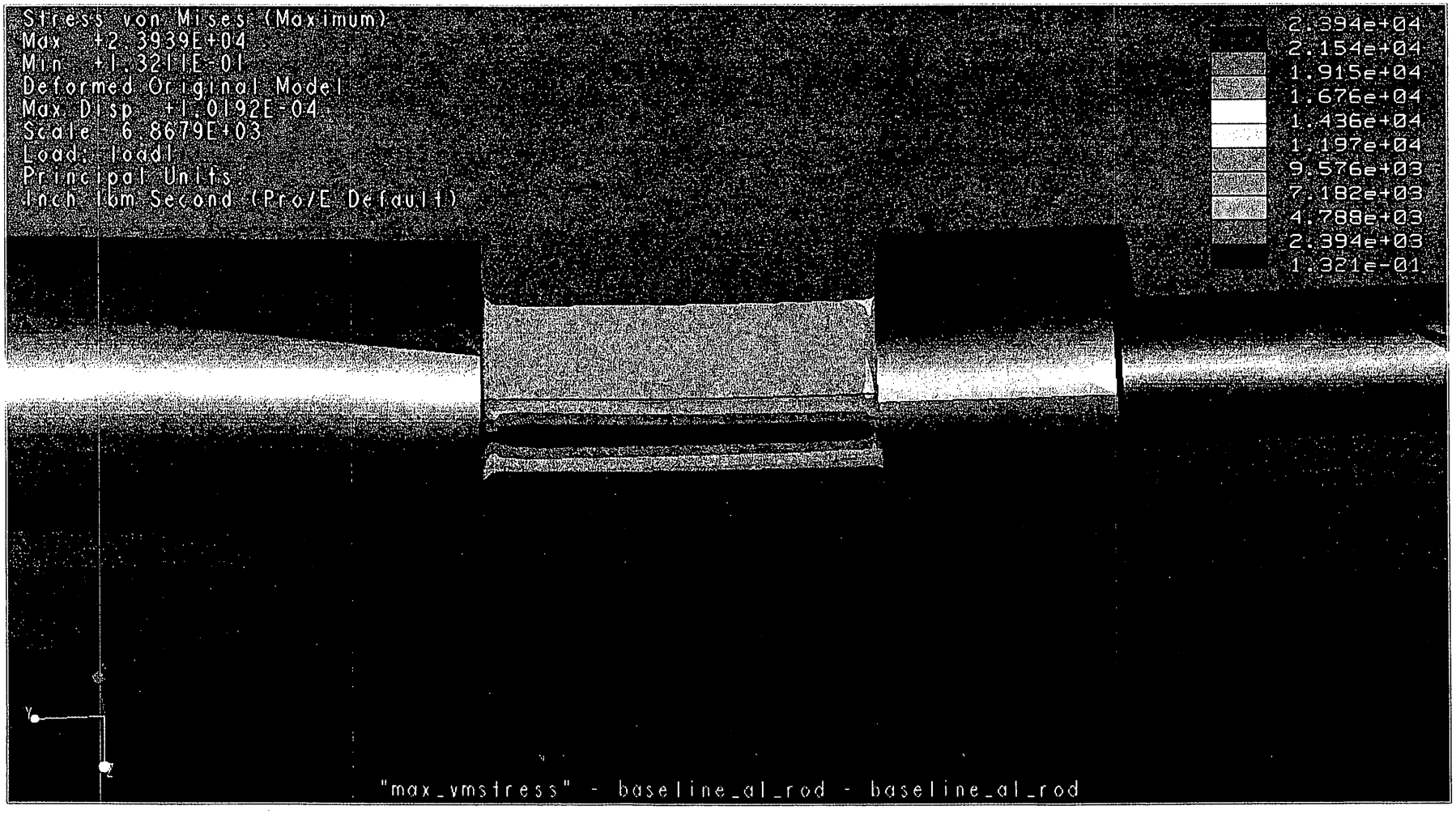
- Needed to know expected stress to meet design criteria
- Needed to know expected displacement to account for in sheath design
- Wanted to know expected life of sensor under fully-reversed maximum loading conditions

Setup of Analyses

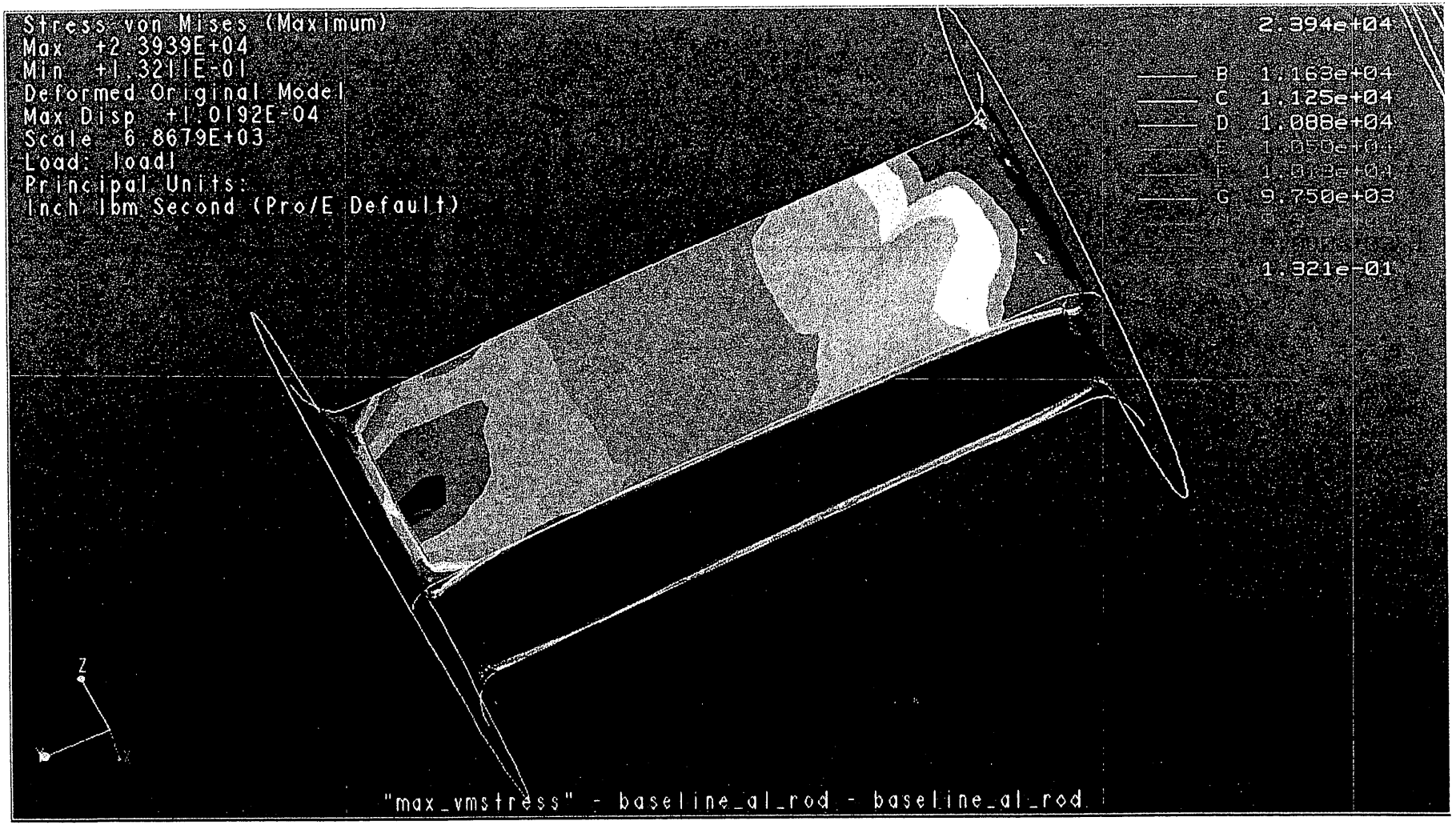
- Forces: Single 5 lbf load at exposed length CG
- Constraints:
  - Fixed in all translation directions at base of beam
  - Fixed in all rotation directions at base of beam



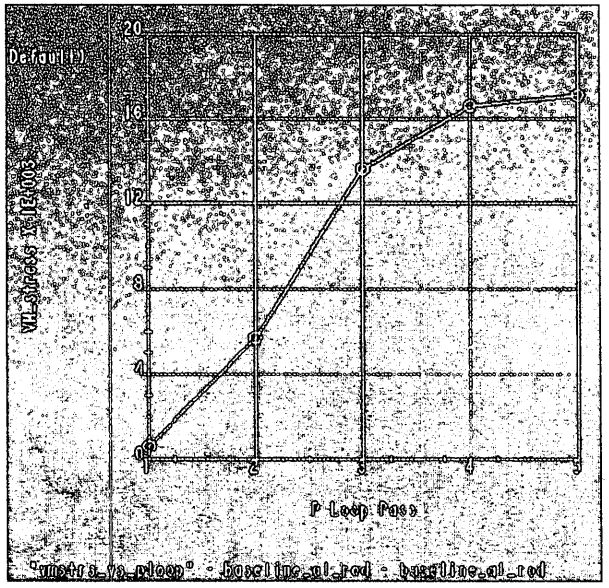
Results of Stress & Displacement Analyses

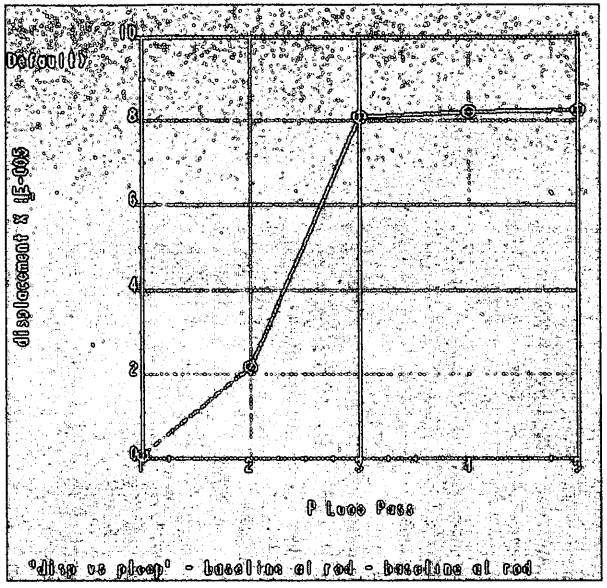


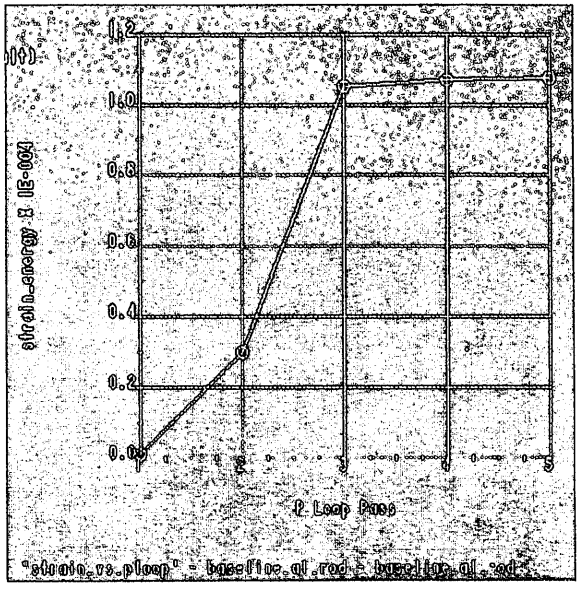
Results of Stress & Displacement Analyses



Is it a proper solution?







- P-level Number
- Bill's 3 Convergence Tests

Bill Paul

Mechanica 2000i class

Result of Fatigue Analysis

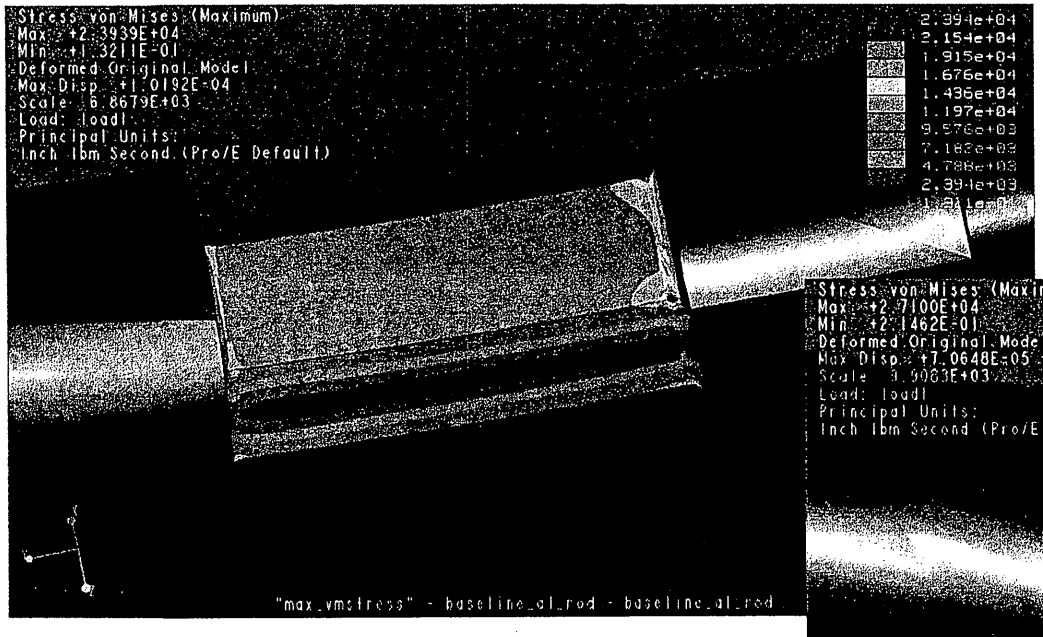
INSERT MATHCAD CALCULATIONS HERE

Optimization of Geometry

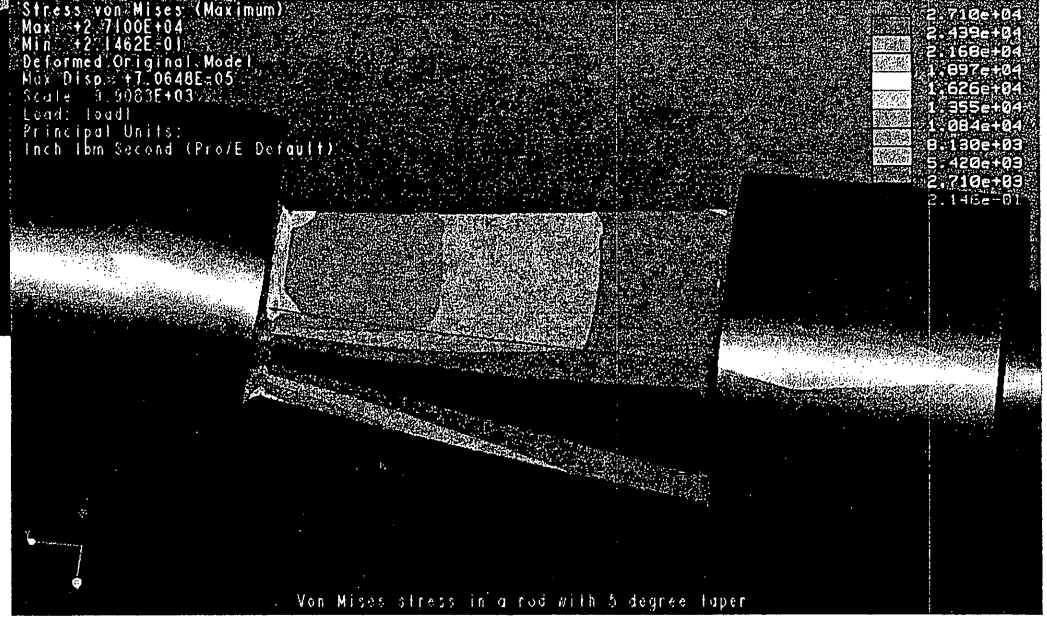
- Wanted to create a more uniform stress profile on strain gage surface
- Wanted to distribute stress concentrations in the part
- Wanted to find the optimal angle for similar stress concentrations

Pro/Mechanica's design optimization tools allowed us to do this

The Need for Optimization

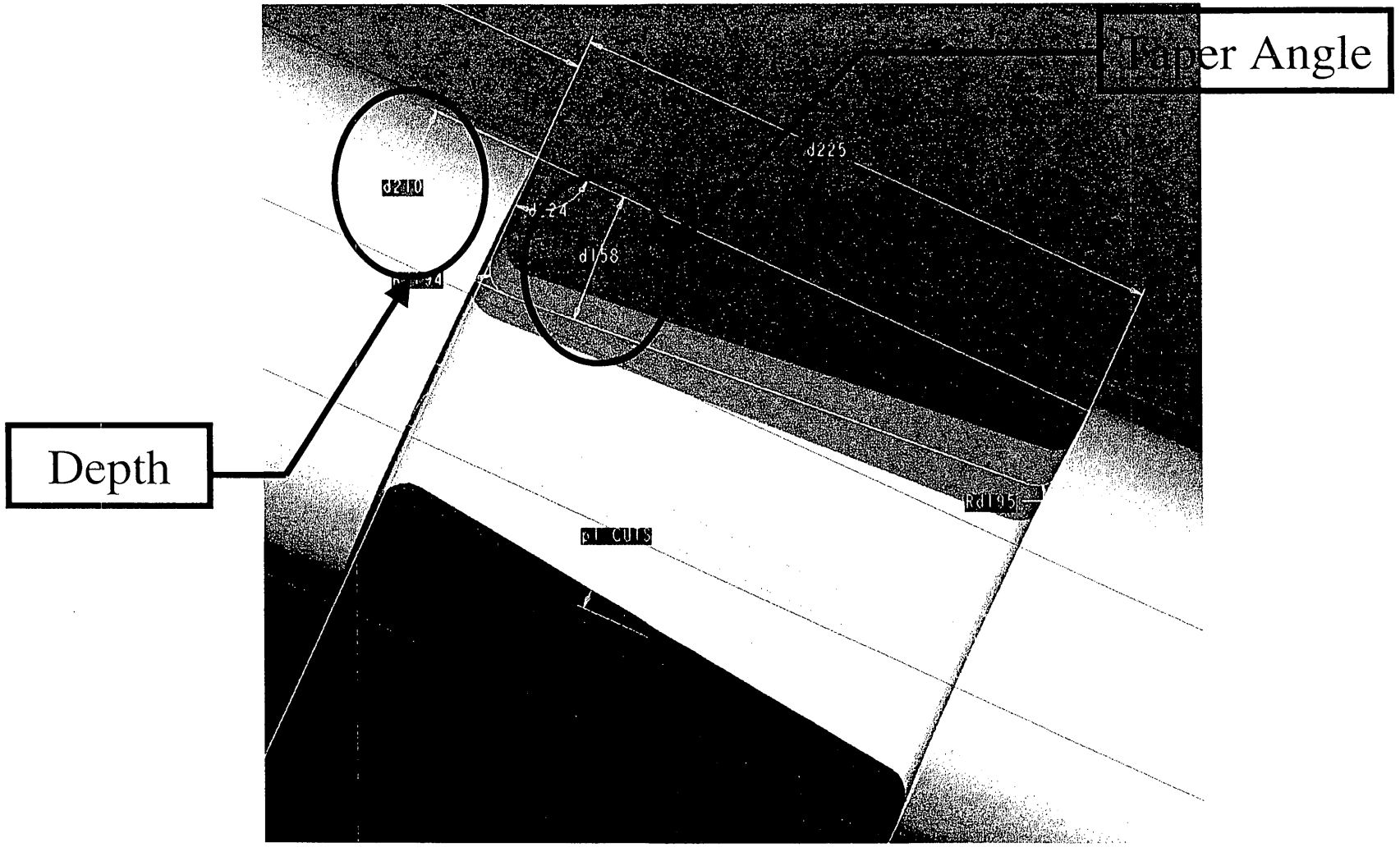


Too Little Taper



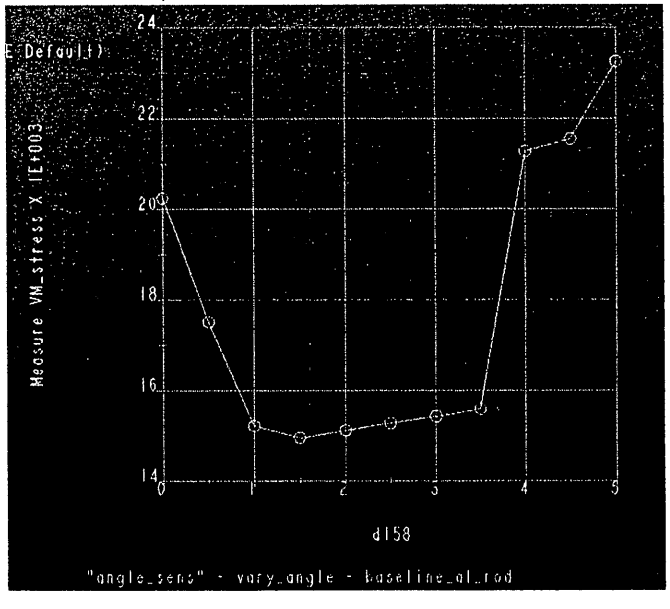
Too Much Taper

Optimization Setup

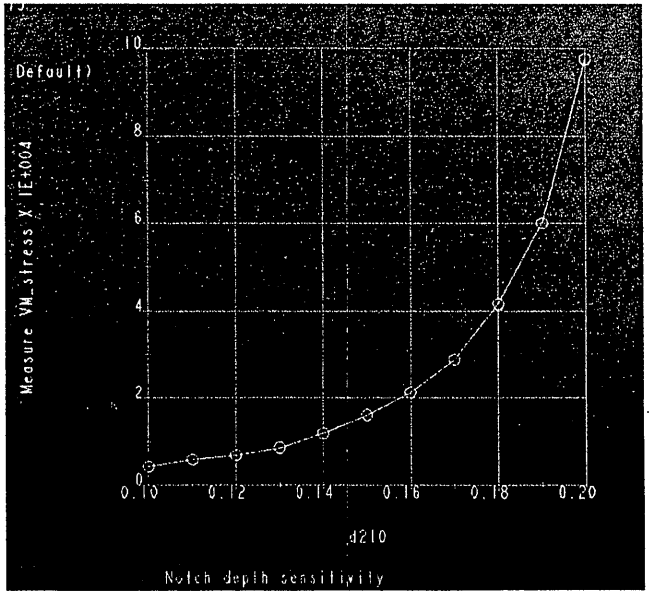


Optimization Setup

- 1st step – Design sensitivity study of the variables
- 2nd step – Optimization of one (or more) variables



Notch Angle



Notch Depth

Results of Optimization

- Larger scope of variables produced undesirable results
- Difficult to specify goals to tailor stress at a location

INSERT DUAL PARAMETER RESULTS FOLLOWED BY ANGLE-DEPTH ONLY RESULTS

Wind Tunnel Testing/Data

- *INSERT WIND TUNNEL DATA HERE!!!*

Vibration Analysis

- Wind tunnel testing showed a high frequency
- Two things happened next:
  - Model was run in Pro/Mechanica to find fundamental frequencies
  - Meanwhile, actual tests were performed with a spectrum analyzer

Results of Vibration Analysis

- Predicted results matched to within .5 Hz for first frequency

INSERT FREQUENCY DISTRIBUTION HERE!!!

CFD Analysis

- External flow around a cylinder

The Final Model

- Notch Depth:
- Notch Taper Angle:
- Stress at full load:
- Displacement at full load:

INSERT PICTURE OF PRO/E MODEL OF EXPLODED ROD ASSEMBLY

Desired Additional Functionality

- Fatigue Calculations – now available in Pro/Mechanica
- Internal Pro/Mechanica creation of animation files – coming soon
- Varying of Material Properties for Design Studies/Optimization
- Implementation of regions for creating design goals/limits

Alternate Scenarios

- Model a wind "profile" – would require transient Loads, which can be done in Pro/Mechanica
- Quantify/Verify wind loads – would require CFD program which we now have (CFDesign)
- Look at the vortex shedding frequency (CFDesign)
- Create basic shape from BMX calculations (vary material, shape)

Questions?

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